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Changes in the proportion of young birds in the hunting bag of Eurasian wigeon: long-term decline, but no association with climate

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Abstract

The proportion of first-year birds in annual wing samples provided by hunters has been used as a measure of breeding success in waterfowl. The proportion of first-year birds in the wing samples of Eurasian wigeon (*Mareca penelope*) from Denmark and the United Kingdom shows a long-term decline, probably reflecting a decrease in breeding success. However, previous studies report conflicting results in the relationship between variation in the proportion of first-year birds and variation in climatic conditions. We used wing data of hunter-shot Eurasian wigeon from Finland to study whether the proportion of first-year birds shows a similar long-term decline and whether between-year variation in the proportion of young is associated with variation in climatic conditions. We found a long-term decline in the proportion of first-year birds. The proportion of young also varied considerably between years, but this variation was not associated with weather or the climatic variables considered for the breeding and wintering periods. More research is needed concerning factors that affect long-term changes and annual variation in the proportion of young in the hunting bag and on the suitability of this index to measure productivity in ducks.

Keywords: age ratio, breeding success, climate, hunting bag, temperature

Introduction

Variation in reproductive success can be an important driver of vertebrate population dynamics, especially when populations are well below carrying capacity (Sæther et al. 2016). Such variation is often caused by environmental stochasticity. For example, weather-driven changes in food supply may have strong impacts on the number of recruits produced and hence limit the abundance of populations (Newton 1998; White 2008). Changes in weather conditions in turn are usually driven by large-scale climatic patterns such as the North Atlantic Oscillation (NAO; see Hurrell et al. 2003; Kucharski et al. 2006; Hurrell and Deser 2010). Information on the variation in reproductive success, and on the role of climatic factors in driving this variation, is thus important for understanding changes in population size.

Alarming signs indicate that Eurasian wigeon numbers (*Mareca penelope*; hereafter, wigeon) are declining in the main EU breeding areas in Finland and Sweden (Pöysä et al. 2013, 2017a; Lehikoinen et al. 2016). Wintering numbers in the northwest Europe flyway have also declined since the mid-2000s (Fox et al. 2016a). Reasons for the long-term population decline are not known, but the deterioration of habitat conditions may have had an effect, as many other species living in same habitats have also declined (Pöysä et al. 2013, 2017a; Lehikoinen et al. 2016). Variation in reproductive success has also been suggested as an important driver of year-to-year variation in wigeon flyway abundance (Fox et al. 2016a).

An unfortunate and crucial shortcoming with most of the important huntable waterfowl species in Europe is that we lack reliable flyway-level information on reproductive success. In geese, the percentage of juveniles in wintering flocks has been used as a measure of annual productivity (e.g. Alisauskas 2002; Patterson and Hearn 2006). A similar proxy for productivity has been developed for wigeon, based on the proportion of first-year birds in annual wing samples provided by hunters and field counts (Mitchell et al. 2008; Clausen et al. 2013; Fox et al. 2015, 2016b; hereafter, the proportion of young). Results from these studies are promising, but additional analyses and data from other parts of the flyway are needed before this measure can be generally accepted and used. In addition, we need more studies addressing changes in annual proportions of young and factors that drive these changes.

Three earlier studies, partially using the same data, have documented a decline in the proportion of young amongst hunter-shot samples from the United Kingdom and Denmark (Mitchell et al. 2008; Christensen and Fox 2014; Fox et al. 2016a). Based on the idea that the proportion of young measures reproductive success, these studies also analysed associations between the proportion of young and weather factors, but reached mixed conclusions. While Mitchell et al. (2008) found the proportion of young (UK and Danish samples) to be positively correlated with breeding ground temperature in June, Christensen and Fox (2014) found no correlations between May, June or July temperatures in the breeding grounds and the proportion of young for wing samples from Denmark. Fox et al. (2016a) in turn reported that the proportion of young (Danish samples) increased with a combined May–July NAO index; however, this result was based on a mistake in the analysis, and no such relationship exists in a corrected analysis (see erratum in the online version of Fox et al. 2016a). Christensen and Fox (2014) also studied the possible impact of wintering conditions, as indexed by NAO values in the preceding January–February, on the proportion of young birds, but found none. Hence, we still do not have an understanding of possible drivers of year-to-year variation in the proportion of young. Neither do we have consistent support for the idea that the proportion of young measures reproductive success accurately enough, assuming that weather and climatic factors affect reproductive success.

In general, the proportion of young amongst samples of shot ducks shows a declining trend towards the southern part of the flyway (Mitchell et al. 2008; Guillemain et al. 2010, 2013), probably bringing about noise in the wing data provided by hunters from various parts of the flyway. Finland has the highest breeding numbers of wigeon amongst European countries, and is closer than Denmark and the UK to the main breeding areas further east (Hagemeijer and Blair 1997). The UK and Denmark are within the wintering range of wigeon breeding in Finland, and most overseas recoveries of wigeon ringed in Finland, mainly ducklings, come from UK, France, Denmark and the Netherlands (Saurola et al. 2013). In this paper, we study whether wing data of shot birds from Finland show a long-term decline in the proportion of young wigeon. In addition, we study whether between-year variation in the proportion of young is associated with weather and climatic conditions in the breeding and wintering areas.

Material and methods

Data

The collection of wings of shot ducks was organized by the Finnish Game and Fisheries Research Institute (since 2015, Natural Resources Institute Finland) during 1966–1988, 2005–2007 and 2014–2016. These sampling schemes have provided nationwide samples of wings of shot birds for a number of duck species (e.g. Pirkola and Lindén 1972; Alhainen et al. 2010). Here we use data of wigeon wings. Age (young, adult) of each shot wigeon amongst the annual wing samples was determined for years 1980–1988 (annual sample size 102–307) of the first sampling period (MK Pirkola, unpublished data; age determination by MK Pirkola, A Salminen and V-M Väänänen) and for all the years of the two recent sampling periods (annual sample size 129–216 in 2005–2007 and 140–189 in 2014–2016; age determination by V-M Väänänen), and the proportion of young was calculated for each year.

Our time series include missing years and therefore are not fully comparable with data of previous studies. To make our analyses and results as comparable as possible with previous studies we used the same climatic and weather variables, from the same location as Christensen and Fox (2014) and Fox et al. (2016a). Specifically, we used mean May, June and July temperatures from the Berezovo Airport weather station (63°93' N 65°05' E; weather station 236310) (https://en.tutiempo.net/climate/ws-236310.html) to measure summer temperatures (cf. Christensen and Fox 2014) and the combined May–July NAO index to indicate overall climatic conditions at the breeding grounds; positive summer NAO indices are assumed to mean favourable breeding conditions for wigeon (warm and dry; good for duckling survival), whereas negative indices should mean unfavourable breeding conditions (cold and rainy; bad for duckling survival) (Fox et al. 2016a; see also Folland et al. 2009). Summer temperatures from the Berezovo station are suitable for wigeon shot in Finland, because birds from northwestern Russia and Finland share the same flyway (Scott and Rose 1996), as also proved by ringing recoveries (Saurola et al. 2013). Breeding numbers of wigeon are much higher in European Russia (c. 220 000–230 000 breeding pairs; Viksne et al. 2010) than in Finland (c. 60 000–80 000 breeding pairs; Hagemeijer and Blair 1997). Peaks in numbers of staging wigeon observed in late September and October in central Finland (Väänänen 2001) most probably represent birds originating from Russia, and these birds are shot by Finnish hunters. In addition to summer weather conditions, we used the winter NAO index (combined December–March) to study whether climatic conditions in the preceding winter affect the proportion of young. We note that Christensen and Fox (2014) used separate January and February NAO indices for the winter period in their analyses. However, the combined December–March NAO index is a more widely used large-scale measure of climate (e.g. Hurrell et al. 2003; Kucharski et al. 2006; Hurrell and Deser 2010; see also Pöysä and Väänänen 2014 and references therein). Positive winter NAO indices mean benign conditions (warm and rainy) in the wintering areas of wigeon, whereas negative winter NAO indices mean hard wintering conditions (cold and dry; see Christensen and Fox 2014). Winter severity could affect the body condition of wigeon females and hence subsequent breeding success. Of course, monthly indices are correlated with the combined winter NAO index; monthly indices gave qualitatively similar results as the combined index (results not shown). Monthly NAO indices were obtained from the website of the Climatic Research Unit at the University of East Anglia (http://www.cru.uea.ac.uk/~timo/datapages/naoi.htm).

Statistical analyses

Because we wanted to test predictions that were based on previous findings of the association between the proportion of young and climate/weather variables (see above), we only considered pre-defined predictors and performed linear regressions with the proportion of young as the dependent variable. All variables met the assumptions of parametric regression. Linearity and homoscedasticity were checked from the plots of residuals versus predicted values and the normality of variables was tested with the Kolmogorov-Smirnov one-sample test. Collinearity amongst predictor variables was low (all pair-wise correlations $|r| < 0.45$, Table 1; see Dormann et al. 2013); hence, we considered all the predictors in the final analyses. May temperature, June temperature and winter NAO showed a significant positive trend over the study period (Table 1). Therefore, to avoid spurious associations between the proportion of young and these climate/weather variables (see Lindström and Forchhammer 2010; Iler et al. 2017), we included year as a predictor in a multiple regression with the proportion of young as the response variable (Freckleton 2002). We also used residuals from regressions between year and the proportion of young and climate/weather variables (i.e. year-detrended values) in linear regressions (see Iler et al. 2017) and obtained similar results (not shown) as derived from multiple regressions with year included as a predictor.

Results

The proportion of young showed a significant long-term decline (linear regression, $\beta = -0.551$, $t = -7.362$, $p < 0.001$, $n = 15$; Fig. 1). Between-year variation in the proportion of young was also considerable (see Fig. 1). Preliminary analyses suggested that the proportion of young tended to correlate negatively with mean daily temperature in May ($r = -0.487$, $p = 0.066$, $n = 15$) and June ($r = -0.457$, $p = 0.087$, $n = 15$) and with the NAO index of the preceding winter ($r = -0.443$, $p = 0.098$, $n = 15$), although none of the correlations was significant. When year was included as an additional predictor in the multiple regression (see Material and methods), none of these predictors explained between-year variation in the proportion of young (Table 2); the effect of year was strong in all cases. Nor was between-year variation in the proportion of young associated with mean daily temperature in July or with summer NAO (Table 2).

Discussion

We found a long-term decline in the proportion of young in samples of hunter-shot wigeon from Finland. The proportion of young varied considerably also between years. However, this variation was not associated with the weather and climatic variables considered, either from the breeding grounds or the wintering period.

Our results confirm earlier findings from Denmark and the UK (Mitchell et al. 2008; Christensen and Fox 2014) in that the proportion of young has declined in samples of hunter-shot wigeon. As to possible drivers of the between-year variation in the proportion of young, our results contradict with Mitchell et al. (2008), but are in line with Christensen and Fox (2014), in that the proportion of young did not vary in response to weather and climatic conditions. Similarly, a corrected analysis of the data in Fox et al. (2016a) did not find a correlation between the proportion of young and combined May–-June NAO index (see erratum in the online version of Fox et al. 2016a). In addition, while Mitchell et al. (2008) found that the proportion of young was positively correlated with breeding ground temperature in June, our results suggested the opposite for temperature in June (and May). We would like to note, however, that when the long-term trend in both the response variable (the proportion of young) and the predictor (temperature) was taken into account, summer temperature did not explain any of the between-year variation in the proportion of young. It is not clear from Mitchell et al. (2008) whether a similar spurious correlation was possible and considered in their analysis. Finally, that we did not find an effect of winter NAO on the proportion of young in wing samples from the subsequent autumn is in line with the finding by Christensen and Fox (2014).

Even if we assume that the proportion of young in the autumn hunting bag reflects breeding success, the expected relationship between breeding success and summer weather conditions may not be straightforward. Cold-hardiness of newly hatched wigeon ducklings is relatively high, higher than for example in the mallard (*Anas platyrhynchos*) and Eurasian teal (*A. crecca*) (Koskimies and Lahti 1964). Wigeon ducklings may be relatively resistant to low temperatures and, hence, not particularly sensitive to direct weather-caused mortality, but this has not been studied in the field. Adverse weather conditions may decrease food availability, and per capita breeding success in wigeon has been found to be affected by food availability (Gardarsson and Einarsson 1997; Elmberg et al. 2003). On the other hand, Arzel et al. (2014) did not find adverse effects of precipitation and low temperature during the first week after hatching on brood size, a measure of breeding success, in mallard and teal in a study conducted in southern Finland.

Contradicting results of the importance of weather and climatic factors in affecting the proportion of young wigeon may be due to the proportion of young in samples of hunter-shot birds being vulnerable to a number of error sources. Several earlier studies have discussed possible problems associated with the use of juvenile proportions in wing samples of hunter-shot birds, or in field counts from staging and wintering areas, to indicate breeding success in wigeon (e.g. Mitchell et al. 2008; Clausen et al. 2013; Fox et al. 2015, 2016b). In particular, differences in the timing of autumn migration between sexes and age classes, and possible between-year variation in this, is a confounding factor that may bring about considerable uncertainty in the index and thus affect its reliability in measuring breeding success. An additional problem, not explicitly considered in previous studies, may arise from the commencement of wigeon autumn migration in general being delayed considerably during the last three decades, at least in Finland (Lehikoinen and Jaatinen 2012). As discussed by Lehikoinen and Jaatinen (2012), this delaying process may continue due to increasing autumn temperatures. Indeed, recent models predict that, due to later freezing and earlier spring thaw, the ice cover period in Nordic lakes will shorten considerably in upcoming decades (Gebre and Alfredsen 2014; Gebre et al. 2014), allowing wigeon and other waterfowl to remain longer in the breeding areas. If differences occur between sex and age classes in this delay, it may bring about changes in age- and sex-specific hunting mortality along the flyway. This in turn could affect the proportion of young in wing samples provided by hunters from various parts of the flyway and probably contribute to long-term changes in the index. For example, if juveniles remain longer in the breeding areas and gain better body condition before autumn migration, they may be less vulnerable to hunting (e.g. Hepp et al. 1986). This could decrease the proportion of young in samples of hunter-shot birds. Clausen et al. (2013) found the within-season variation in the proportion of young among male wigeon shot in Denmark to be consistent between years but, as acknowledged by the authors, their study period was short (2002/2003–2011/2012); more years would be needed to fully address possible changes in age-specific migration phenology and its effect on the proportion of young in the hunting bag.

Furthermore, we need to keep in mind that a considerable proportion of wigeon are shot along the flyway before reaching the southern staging and wintering areas (e.g. Guillemain et al. 2016). The proportion of young in the hunting bag is much higher in the breeding areas than in the staging and wintering areas. For example, in the data compiled by Guillemain et al. (2013: Table 1; mean values, sexes combined), the proportion of young was 78% in wing samples from Finland but only 58% and 50% in wing samples from Denmark and the UK, respectively (see also Mitchell et al. 2008). Most of the decrease probably reflects an effect of hunting mortality. We do not know how consistent these geographical differences are between years and in the long term, although Mitchell et al. (2008) found that the annual proportions of young in the Danish and UK samples were correlated. Anyhow, because climate change already has been found to affect migration phenology (Lehikoinen and Jaatinen 2012) and winter distribution of the species (Fox et al. 2016b), changes in the distribution of the hunting bag along with changes in the sex- and age-composition of the hunting bag are possible along the flyway. We suggest that possible confounding effects of these factors should be studied in detail before wing samples and field counts are generally used to measure breeding success in the species. Nevertheless, extreme values in the proportion of young may reveal years of exceptionally bad or good reproductive output as exemplified by the UK and Danish wing data from year 1992 (Mitchell et al. 2008; Christensen and Fox 2014); the eruption of Mount Pinatubo volcano in June 1991 resulted in exceptionally cold weather conditions and breeding failure of waterfowl and waders in the Northern Hemisphere in summer 1992 (Ganter and Boyd 2000). Furthermore, in geese, the proportion of young in autumn and winter has been found to associate with adult female nutritional state in previous spring, breeding time weather conditions and changes in predation pressure in the breeding areas (e.g. Summers et al. 1998; Alisauskas 2002; Trinder et al. 2009). These findings support the idea that the proportion of young in autumn reflects breeding success at least in geese; it is reasonable to assume that this could also work for ducks.

To conclude, the proportion of young in samples of hunter-shot wigeon shows a consistent long-term decline, probably indicating an overall decrease in productivity. However, the proportion of young in the hunting bag may vary due to reasons unrelated to breeding success per se. We do not, as of yet, have consistent support for the idea that variation in the proportion of young wigeon is driven by weather and climatic factors. Our current understanding of potential confounding factors is insufficient, limiting the use of the proportion of young as a measure of annual breeding success. Moreover, a measure based on the proportion of young in wing samples from autumn does not allow identifying causes of low (or high) breeding success; a low proportion of young in autumn may be indicative of low breeding propensity, small clutch size, low nest success or low duckling survival. Information on actual causes of variation in breeding success is urgently needed to understand population dynamics and long-term population changes of wigeon and to efficiently manage the populations of wigeon and other duck species in Europe. In particular, because earlier studies suggest that long-term population declines of many duck species are connected with changes in habitat quality (Pöysä et al. 2013, 2017a, b; Lehikoinen et al. 2016), the role of habitat deterioration as a global driver of breeding success should receive more attention.

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Table 1 Pair-wise correlations between predictor variables, including year. Significant (at $p < 0.05$) correlations are in bold; n = 15 in all cases

	Year	May temp	June temp	July temp	NAO summer	NAO winter
Year	1.00					
May temp	**0.663**	1.00				
June temp	0.488	0.422	1.00			
July temp	0.075	0.108	-0.161	1.00		
NAO summer	0.180	-0.012	0.425	-0.353	1.00	
NAO winter	0.447	0.217	0.261	0.160	0.040	1.00

May temp = mean daily temperature in May in Berezovo; June temp = mean daily temperature in June in Berezovo; July temp = mean daily temperature in July in Berezovo; NAO summer = combined NAO index from May–July; NAO winter = combined NAO index from December–March in the preceding winter

Table 2 Multiple regressions or pair-wise regressions between the proportion of young and predictors (see Material and methods)

		β	SE	t	p
Proportion of young vs.	May temp	0.589	0.488	1.209	0.250
	Year	-0.629	0.098	-6.411	<0.001
Proportion of young vs.	June temp	-0.129	0.767	-0.168	0.869
	Year	-0.543	0.089	-6.097	<0.001
Proportion of young vs.	Winter NAO	-0.453	1.220	-0.371	0.717
	Year	-0.536	0.087	-6.199	<0.001
Proportion of young vs.	July temp	0.002	0.998	0.002	0.998
Proportion of young vs.	Summer NAO	-4.954	4.451	-1.113	0.286

May temp = mean daily temperature in May in Berezovo; June temp = mean daily temperature in June in Berezovo; July temp = mean daily temperature in July in Berezovo; NAO summer = combined NAO index from May–July; NAO winter = combined NAO index from December–March in the preceding winter

Figure legends

Fig. 1 Changes in the proportion of young in annual samples of hunter-shot Eurasian wigeon from Finland